# CRUSHED STONE JOURNAL


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# Crushed Stone Journal

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NATIONAL CRUSHED STONE ASSOCIATION

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## Contents

# Maximum Size Aggregate for Crushed Stone Base Courses, Macadam Type

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WITH our expanded highway program it becomes even more important to consider all possible savings that will accomplish satisfactory results. Often it is difficult to determine what may be considered satisfactory results. However, important considerations in road construction are good riding qualities and a minimum amount of maintenance.

It costs money to manufacture crushed stone and the finer the material has to be crushed the greater the cost. In addition to crushing the stone it also costs money to screen and process this material. We are therefore vitally interested in two factors:

1. Maximum Size
2. Gradation Limitations

This article deals only with crushed stone base course as this might well represent a greater volume than wearing courses constructed with crushed stone. However, many of the factors to be considered in maximum size and gradation limits for crushed stone base courses also apply to bituminous macadam and bituminous concrete construction.

### Crusher Run Material

This term frequently appears in specifications and might normally attract attention as being the most economical type of material to manufacture. Usually specifications provide, in addition to a maximum allowable size, further gradation requirements. A statement that the material shall be a complete crusher run is merely a statement or requirement to prevent the manufacturer from taking out of the product certain sizes, usually smaller sizes, that will command a higher price than the coarse stone. It might be possible to take out these sizes and keep within the limits of the specifications by staying close to the upper or coarse limits of the requirements.

Crusher run with only a top size limitation can be of such a variation as to seriously affect the quality of the material. This can be shown by using gradation curves for various types of crushers. The following curves were obtained from "Handbook of Mineral Dressing" by Taggart. On the basis of these curves and using a 4 in. limiting aperture, we obtain the following gradations:

SIZE DISTRIBUTION

| | Reduction Crushers | | | | | Jaw Crusher Product | | |
|---|---|---|---|---|---|---|---|---|
| Sieve Size | Wet Tumbling Mill | Primary Gyratory Straight Element Breaking Head and Concaves | Standard Cone Crusher | Hammer Mill, No Cage | Rolls, Open Circuit Free Crushing Slow Speed | Medium Tough or Slabby Rock | Sized Feed on Easily Crushed Rock | Easily Crushed Rock Run of Quarry Feed |
| | Per Cent Passing | | | | | | | |
| 4 in. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 3 in. | 94 | 90 | 87 | 90 | 76 | 84 | 91 | 97 |
| 2 1/2 in. | 90 | 85 | 80 | 79 | 63 | 75 | 84 | 91 |
| 2 in. | 86 | 78 | 72 | 68 | 51 | 65 | 75 | 85 |
| 1 1/2 in. | 80 | 69 | 63 | 55 | 42 | 55 | 65 | 75 |
| 1 in. | 70 | 55 | 48 | 39 | 30 | 40 | 50 | 60 |
| 3/4 in. | 63 | 45 | 40 | 31 | 24 | 33 | 41 | 51 |
| 1/2 in. | 52 | 34 | 29 | 22 | 17 | 24 | 31 | 40 |
| 3/8 in. | 46 | 28 | 23 | 18 | 14 | 18 | 25 | 34 |
| No. 4 | 30 | 16 | 13 | 10 | 8 | 11 | 15 | 22 |
| No. 8 | 20 | 10 | 8 | 6 | 5 | 6 | 8 | 14 |
| No. 16 | 11 | 5 | 4 | 3 | 2 | 3 | 5 | 11 |
| No. 30 | 5 | 2 | 2 | 1 | | 1 | 3 | 7 |
| No. 50 | 3 | 1 | | | | | 1 | 3 |
| No. 100 | 1 | | | | | | | 1 |

Naturally these gradations are only an approximation but they do serve to show the large variation in the same material due to varying the type of crusher.

Another factor which can be serious is how clean the quarry is operated, that is, how complete is the stripping operation, has all the overburden been removed, and is there any natural or disintegrated stone that caps the quarry or occurs in seams that might affect the crusher run product. It is obvious that it would be hazardous to permit the use of a straight crusher run product in a stone base construction without controlling the gradation limitations.

Large Piece of Stone Passing a 6 in. Square Mesh Screen Only Twice the Opening of the Screen Gives a Length of 12 in.

Placing 4 in. Maximum Size Aggregate With Mechanical Stone Spreader

Large Size Stone Segregating to the Edge of the Crushed Stone Base Course and Bad Segregation Occurring When Using 6 in. Maximum Size

Uniformly Graded Base Course Using 4 in. Maximum Size Crushed Stone

Segregation and Lack of Uniformity Due to Oversize Stone Note Large Stone With Lens Cap on Top of Stone for Contrast

Completed Crushed Stone Base Course After Voids Filled With Crusher Dust or Sand

### Stockpiling

The first problem to consider after the manufacture is stockpiling, if the material is not taken directly from the crushing plant to the project. It is well known that segregation is one of the major problems of stockpiling. Segregation is directly related to gradation. For example, if a one size product is being manufactured there would be no segregation regardless of how the stockpile was constructed. When there is a large variation from top to bottom sizes, segregation is bound to occur and the larger sizes will roll down the pile leaving the finer material in the core of the stockpile. One method of minimizing the segregation is to construct the stockpile in layers and remove the material from the stockpile in a similar or reverse manner. Regardless of how the stockpile is handled, if the variation from the top size to the smallest size is great but uniformly graded, there is always the problem of segregation. The greater uniformity will always be obtained the nearer the product approaches a one-size aggregate.

### Placing

While segregation is a problem in stockpiling crushed stone, there is also a serious problem in placing or constructing a crushed stone base course. A skilled road builder can easily detect lack of uniformity in this type of construction. When segregation occurs there will be sections of coarse size stone and adjoining sections of fine stone. Furthermore, there may be long slivery pieces or flat disc like pieces that bridge over many of the normal sized pieces of crushed stone. Any of this type of construction can be serious and result in an inferior pavement. This inferiority is largely due to variations in density and supporting value of the base course. A great hazard is that the effect of this type of construction may not show up for several years due to the length of time required for particle orientation due to traffic compaction.

A good example of what might happen in this type of construction was reported in Volume 25 of the 1956 Proceedings of The Association of Asphalt Paving Technologists by the author under title, "Construction of the Maine Turnpike." On this particular project a 3 in. maximum size crushed stone was used for the base course. It was necessary to route the trucks hauling the crushed stone over the newly constructed base course and it became evident that some displacement was occurring. As described in this article, plate bearing tests were made on the subgrade as well as on the newly constructed base course and it was determined that the gravel base course showed an equivalent CBR of 100 while that of the overlaying crushed stone base course varied from 43 to 100. This showed clearly that no movement was occurring in the gravel base course and all of the displacement was due to lack of density in the crushed stone base course. It was necessary to re-roll these areas using a special procedure until a CBR equivalent of 100 was obtained. The specification was then altered using a smaller size aggregate as described in this article which corrected all of the difficulties and it was possible to obtain good compaction with a normal rolling procedure. It is entirely possible in this particular project if the trucks had not been routed over the crushed stone base course that the entire project might have been completed without further compaction of the stone base course. This would have resulted in poor riding qualities, especially after a few years of traffic that would have consolidated the base course.

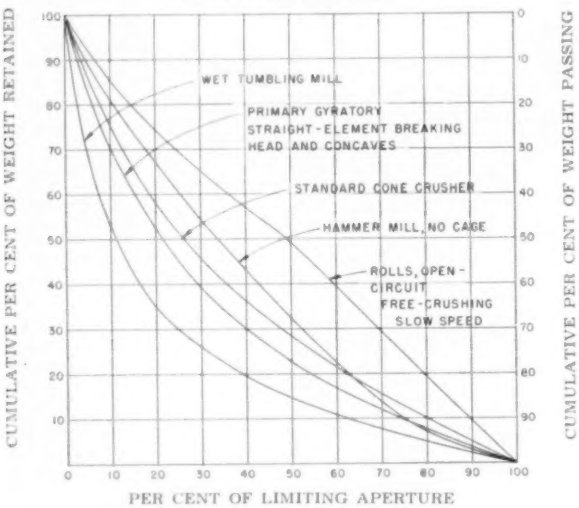
### General

As recent as the late 30's and still somewhat in use has been the construction of a stone base course with so-called "one man stone," meaning stones of from 8 in. to 12 in. in diameter that were used in this type of construction and the maximum size of the stone was often nearly the thickness of the base course. Excellent base courses were constructed in this manner. It must be remembered, however, that this was a hand placed operation and not one which was mechanically spread. These base courses were skillfully constructed. They were well chinked and uniform. The type of construction described in this article deals only with crushed stone to be placed by mechanical methods.

Recently we had some experience with a project specifying a 6 in. maximum size aggregate for a crushed stone base course. It was impossible to obtain uniform results with a mechanical spreader. In fact, it was possible to obtain better results spreading the crushed stone with a bulldozer than with a conventional stone spreader. Regardless of the method used there was a lack of uniformity and therefore a lack in the supporting value of such a base course. Unfortunately, such a lack of supporting value might not become apparent immediately and could conceivably result in a finished pavement becoming progressively rougher after several years of traffic. This would be due to particle orientation under traffic increasing density of the base course. As a result of this condition experiments were conducted reducing the top size of the aggregate by

stages to determine at what point the crushed stone could be spread satisfactorily with a conventional stone spreader. It was finally determined that with a maximum size of 4 in. and a uniformly graded product, satisfactory and uniform results could be

SIZE DISTRIBUTION CURVES FOR
REDUCTION CRUSHERS




obtained when using a conventional stone spreader. Of equal importance was the gradation control of the crushed stone and to maintain these limitations within reasonable limits then and then only was it possible to maintain a uniformity that would permit a uniform application of filler to complete the crushed stone base course.

The type of stone being crushed has a considerable influence on the particle shape. In general, trap rock tends to break in flat and elongated particles more than granite. A reduction of the maximum size is one method of reducing the per cent of flat and elongated particles. Therefore, a specification that might be satisfactory for one type of stone may not be equally as satisfactory with another type of stone.

## Conclusions

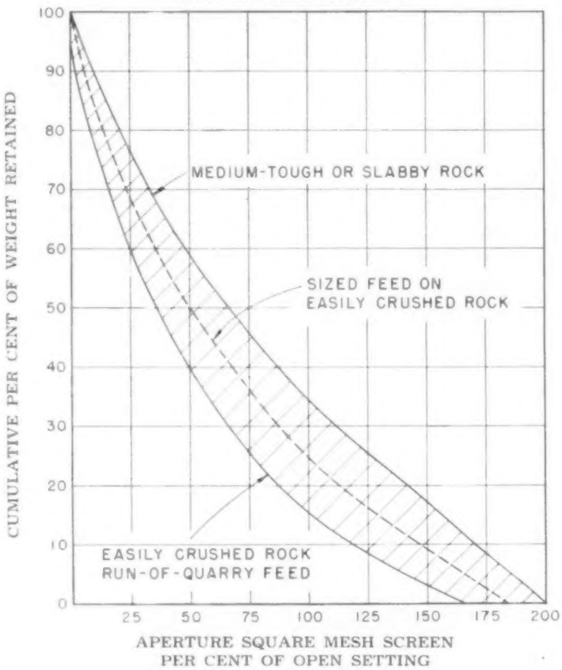
1. It is the opinion of the author that the maximum size of crushed stone that can be spread with a conventional stone spreader is 4 in. This applies only to that type of stone that does not tend to break in flat and elongated particle shapes.

2. As this size of stone is not normally included in specifications, the following gradation limitations are recommended, applying only to that type of rock which does not tend to break in flat and elongated particles:

| Sieve Size | Per Cent Passing |
|---|---|
| 4 1/2 in. | 100 |
| 4 in. | 95-100 |
| 1 1/2 in. | 35-60 |
| No. 4 | 0-10 |

3. Crusher run material without processing by screening and removing fine size material should not be permitted as it would undoubtedly result in variable densities and displacement problems as well as possible contamination by frost susceptible and organic material.

SIZE DISTRIBUTION
JAW CRUSHER PRODUCT




The term "crusher run" is misleading and should not be included in specifications without gradation limits. Some other method should be used to prevent the scalping of smaller sized stone from the crushed product if that is the intent of such a requirement. One method of accomplishing this result would be to establish variation or tolerance limitations on an accepted product within the specification limits.

4. In general, the maximum size of crushed stone should be such that the material can be spread by mechanical spreader to produce a uniformly graded base course, free from segregation and of such a gradation that the base course may be compacted to support the designed load without displacement.

# The Transportation Revolution: Highway Transportation[1]

By E. H. HOLMES

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### The Past

HIGHWAY transportation as we know it today—more specifically motor vehicle transportation—was born in 1893 when J. Frank Duryea made the first successful run in his Buggyat in Springfield, Massachusetts.

It survived a precarious childhood of some twenty years before it began in the early days of the century an adolescent growth that led to maturity, or a full fledged adult in our national economy, at the time of the great depression. Since then it has been moving ahead at a pace almost identical with the growth in the economy.

In actual figures a preliminary estimate of 1957 traffic volumes on all roads and streets is 643 billion vehicle miles, which compares with a figure of less than 50 billion in 1920.

Perhaps it is easier to visualize this growth in relation to other factors by the use of index numbers. Using 1950 as a base year with an index of 100, traffic volumes in 1920 stood at 10. The national economy, as measured by the gross national product and using the same base year of 1950 as 100, stood at 39. The adolescent growth of the twenty's brought travel to a level of 47 in 1931, when it intercepted the curve of the economy as it dropped in the depression from the 1929 level of 56. During this period the use of the motor vehicle changed from sport to transport. It had become a significant force in the economy.

Following 1931 the curves of traffic and the economy have risen in almost identical patterns until the beginning of the war when production shot up and travel was arbitrarily held down. By 1947, however, the curves had come back together and again followed identical paths until 1953. Since then highway travel has shown a somewhat greater rate of growth than the economy, but still follows a nearly parallel course.

It is of interest that traffic volumes declined in 1932 but not so much as did the economy. The rates of growth slackened in 1938, in 1949, and in 1954, reflecting in each case an approximately similar slackening in the growth of the gross national product. In all cases, the losses were regained in the succeeding years, and the earlier trends resumed. For what value it may be, the rate of traffic volume increase in recent months is well below its long time trend, yet in no month has the volume on all roads and streets fallen below the figure for the corresponding month of the previous year. Perhaps this is a good portent.

Now, to mention just one more figure, since 1931 when motor vehicle travel had achieved its maturity in the economy, there has been a mile and a half of travel for each dollar of gross national product, based on the 1956 value of the dollar—again excluding the distorted relation of the war years. It thus becomes a simple matter to forecast travel, if one can but predict the growth of the national economy.

In the early days of the century there was considerable skepticism as to whether the automobile would ever displace the horse, and the possibility that it would ever become a serious competitor with other forms of transportation seemed remote indeed. But the horse has been relegated to what would appear to be more pleasant roles on race tracks and before the television camera, and the maturity of highway transportation has brought with it competition in certain areas that can have far-reaching effects. While the great bulk of motor vehicle use is wholly noncompetitive we cannot fail to recognize the competition that exists between over-the-road trucking and railroad freight movement, and between the private passenger car and public transportation in urban areas.

### Over-the-Road Trucking

Over-the-road trucking was not a significant factor until the advent of the tractor-truck in the late twenty's, which opened the way to moving substantial tonnages long distances at passenger car speeds.

Reliable trends in motor truck use extend back only until 1936, the beginning of the highway planning surveys. These trends show that in the twenty years from 1936 to 1956 travel of trucks and combi-

[1] Presented at The Syracuse Transportation Conference, Syracuse University, April 21, 1958

nations on main rural roads, the area of potential railroad competition, increased 3.25 times. This rate of increase was but little more than the rate for passenger cars, however, and in the two decades the vehicle miles of travel of trucks and combinations increased only from 17 1/2 to 21 per cent of the total travel of all vehicles.

It is within the area of travel of trucks and combinations where the significant change has occurred. Here the percentage of truck combinations in the total of all truck and combination travel increased in the twenty-year period from 17.9 to 32.4, nearly doubling in proportion. With this has come a corresponding increase in ton miles of products moved. The average carried load during this period increased from 2.9 to 6.0 tons, more than double, which when combined with the increased vehicle mileage resulted in an increase in ton mileage on these main rural roads from 28 billion in 1936 to 171 billion in 1956, or a percentage increase of over 500 per cent in the twenty years.

During this period of growth of motor truck transportation there has been a closely similar growth in ton mileage of products transported by waterways and pipelines, so certainly the truck is not the sole factor in the competition for freight movement. As use of other modes of transportation has increased, however, the railroads have not shared in the economic growth of the country. In 1940 railroad ton mileage stood at 375 billion. In the peak war year of 1944 it had risen to 740 billion, and then dropped to 600 billion in 1946, a figure held approximately at that level since then. Even though their total ton mileage has held fairly steady their share of the total has declined in serious degree. In recent years we have been able to use as a rule-of-thumb measure that railroad ton mileage is roughly half the total and the other three principal modes shared the other half about equally, one sixth each. In 1956, the railroad portion was slightly less than half the total, 49.6 per cent, while pipe lines accounted for 17.5, waterways for 16.8, and rural highways for 16.1 per cent.

### Urban Passenger Movement

In the other principal area of competition in transportation we find that the acceptance of the private passenger car has placed public transportation in serious plight and its future in jeopardy.

Motor vehicle travel in urban areas has increased at nearly the same rate as on rural roads. In 1936, urban travel was estimated at 51 per cent of the total, and in 1946, at 50 per cent. Since then the rate of increase in urban areas, perhaps because of congestion itself, has been somewhat less than that on rural roads, until in 1956 the urban travel amounted to but 44 per cent of the total.

Despite this retarded rate of increase, the trend has still been upward, in sharp contrast to the trend in transit travel.

Using the American Transit Association index with the base period of 1936-1940, the figures for 1929 stood at 130. With the depression the index figure dropped below 90 and then climbed to a war time peak of 180. But as private vehicle transportation again became available transit travel began a steady decline, passing through the 100 mark in 1954, reaching 85 in 1955, and for February 1958 standing just under 75. Figures of interest, and, perhaps of some significance, show that between 1950 and 1957 while urban passenger car travel was increasing by 40 per cent, transit travel declined by 38 per cent. Of course, only a small portion of urban motor vehicle travel is competitive with transit, but the similarity between growth of one and decline of the other is striking.

### The Future

Based on that brief review of the past, can we anticipate what lies ahead? Of course we can not look far ahead with great certainty, but the trends of the past must, if their meaning can be understood, offer useful guides. In looking ahead it is well to do so with caution, of course, and in this connection a recent remark by a most competent economist might well be borne in mind. He said he had grave doubts about his ability to foresee the future. Moreover, he said, he was not too confident that he thoroughly understood the present and, if pressed, he might have to admit some question as to his ability to explain the past. And with the widely varying views now often heard as to why we are in the shape we are in today, I, too, wonder whether we really do understand how we arrived here.

There is a striking and very important difference between highway transportation in the United States and in other countries. Foreign highway engineers and administrators visiting this country almost invariably question us on the economic factors and decisions that underlie our highway program. They are concerned with the costs of highway transportation in comparison with that of other modes, particularly rail transportation. They ask what is the economic limit of haul for the movement of goods over the highway, and similar questions that reveal very clearly that outside this country highway transportation is regarded primarily in the field of move-

ment of goods, and it is encouraged or discouraged through deliberate economic decisions. The basis of these decisions is often complex and frequently they are influenced by the fact of public ownership of railroads, by the limitations of national and private resources, or by other social or economic considerations.

These foreign visitors even after observing our highway traffic have difficulty in recognizing why we have today the highway network and the highway transportation system we do. They find it difficult to accept that our highway system, as we know it today, was not conceived and built primarily for the movement of goods or through deliberate economic decisions. It has achieved a place of tremendous importance in our economy, and in fact of itself had a great hand in lifting us to our present economic level. But this nation's highway improvement program came not through deliberate plan of years ago but through the powerful and insistent demands of the American public for the personal transportation the motor vehicle provides. Great as is the economic importance of motor truck transportation, the bulk of our vehicular movement is that of passenger cars—not trucks. And while the motor truck has played an extremely important role in the expanding economy of the nation and in the improvement of the highways themselves, we undoubtedly would have had a fine highway system if only because of the desire of the American people, as expressed by Kettering, to go from here to there sitting down.

But having the highway system, our economy has developed around it to an amazing degree. It is hardly necessary to cite the many ways in which we have come to depend on it. Travel from homes in the more pleasant suburbs and rural areas to office or factory, themselves often located in new and better areas made accessible by highway, is now accepted practice. Use of the car in shopping, in recreational trips to weekend camps or resort areas, social visits or just driving around have become a part of our way of life. The private passenger car is in fact shaping our metropolitan areas. And with it has come also the use of the highway by the motor truck and bus.

#### Motor Truck Transportation

In contrast to the use of passenger cars, the development of truck transportation has been primarily for economic reasons. The speed and flexibility of truck transportation has drawn traffic from the rails, and much is in the high tariff field. It must be recognized, however, that in this area of competition—in the over-the-road movement—where the decision as to the mode of transportation is economic, the actual transportation cost may be a relatively minor factor. Speed of delivery, better condition of product on arrival, ability to handle small shipments and consequent reduction in inventory requirements, elimination of crating and packaging, and many other considerations enter in. The economic decision involves many cost items, and the cost of transportation itself may be far outweighed by other factors.

Not all truck transportation is in the competitive area, of course, for the truck provides supplemental transportation at one or both ends of the haul by other modes of transport. Undoubtedly, also, many commodities are moved today by highway only because of the existence of highway transportation. The motor truck has developed movements that otherwise would not occur, and such movements are in no sense competitive.

Though transportation cost often is not a determinant, and while certain movement is definitely noncompetitive, transportation cost does enter importantly into many decisions, and in such cases the highway system itself is a prominent part of the picture. As highways are improved, vehicle operating costs can be reduced, and with the promise of prompt and marked highway improvement, particularly on the Interstate System, such reductions may well be an increasingly important factor.

To what degree highway transportation costs will be reduced is now the subject of study by the Bureau of Public Roads under the requirement of Section 210 of the Federal-Aid Highway Act of 1956. While not attempting to anticipate the results of work now under way, there are available figures from a variety of sources that give some clue to the savings that improved highways may produce.

Studies by the General Electric Company of truck travel over the New York Thruway compared to the previously traveled route showed savings of 7 per cent in distance, 13 per cent in fuel, 28 per cent in travel time, and 69 and 68 per cent, respectively, in gear shifts and brake applications.

The Indiana Toll Road Commission in test runs between Chicago and Jersey City found savings in distance over other routes of 2 per cent, a saving of 8 per cent in fuel, 22 per cent in travel time, and 75 and 76 per cent in gear shifts and brake applications.

Bureau of Public Roads studies on the Pennsylvania Turnpike several years ago showed a 44 per

cent saving in travel time and a 36 per cent saving in fuel. The saving in fuel, however, resulted very largely from the reduction in rise and fall permitted by the use of the tunnels.

These are only indications, of course, but they point to the possibility of significant savings in truck operating costs. In distance alone the original Interstate System, extending over 40,000 miles of existing roads, is estimated to include only about 38,600 miles in its relocated alinement, a saving of some 3 per cent nationwide. Perhaps little saving in fuel will result, because higher speeds that will be possible will offset the saving from reductions in stops and starts, but reductions in other classes of operating costs are inevitable.

But the greatest potential saving lies in reduced travel time. At present truck operators can take only limited advantage of this factor, because of the prevalence of driver wage contracts based on distance rather than time, and fixed terminal points. As the system is completed, however, it is only logical to expect adjustment in these factors, that will produce lower costs per mile. Beyond that, faster transportation will undoubtedly develop more business, both diverted from other forms of transportation or newly generated.

In summary, then, to repeat a figure used earlier, ton mileage by truck increased six fold in twenty years. The likelihood seems to be that the rate of increase in the years ahead may be even greater.

### Private vs. Public Transportation in Cities

Turning to the other area of competition mentioned earlier, quite a different condition exists. No doubt public transportation as a self-supporting private enterprise is in serious straits. And no doubt also the downtown areas of our larger cities as we see them today, and as they have developed largely because of the pattern of public transportation of the past, are heavily dependent on transit. Thus the way in which people in urban areas choose to travel in the future has implications quite beyond that of transportation alone.

As in the case of the motor truck, not all private passenger transportation is competitive. The availability of flexible personal transportation has changed the place of public transportation in urban life and affected its income base to a degree that often seems to be overlooked. Public transportation in urban areas today has become largely a peak-hour, home-to-work movement. No longer does a family go by street car on Sunday to a beach or other resort. The family no longer takes the street car to the downtown theater. The housewife uses transit only occasionally for shopping. And even the length of the week has changed for the transit company, for there is now little home-to-work travel on Saturday.

The base period business on which transit formerly could depend has largely gone, never to return, not for economic reasons but because of universal availability of a newer and better form of travel. And transit to survive must do so on its peak hour business, with all the attendant difficulties of traffic congestion, the 40 hour week for labor, and other troubles. Remedies often proposed such as reduced taxes and less stringent regulation would seem to be only palliatives, not real solutions to the basic problem resulting from the changed and changing pattern of American life.

Many sincere economists, planners, and specialists in other fields, acutely concerned over the plight of the downtown area, seek to find the solution in the return of patronage to public transportation. Some would encourage it by better service, others by lower fares, even if subsidized, and some by combination of those and other methods.

Still a different approach would force the return of people to transit by a theory called "pricing." Under this plan highway travel would be limited to the designed capacity of the facilities that are built by a charge, through tolls if that were practicable, or through arbitrary taxation to discourage motor vehicle use. This theory is defended on the grounds that public transportation is more efficient, and therefore it is defensible to force its use, and that in so doing the highways become less congested and more attractive to the smaller number of users who are willing to pay an arbitrarily high price for their use.

This last theory I reject out of hand. It would be impracticable to operate, for certainly all highway users cannot be charged arbitrarily to prevent some few from using their vehicles. Secondly, public transportation cannot by its very nature serve the people in the fringes of the expanding urban areas where the great growth of the population will take place in the years ahead.

But more importantly, even if it were conceded that public transportation is more efficient, we cannot force upon all the people measures that are conceived by a few to be best for them on the grounds of greater efficiency. The great economic growth of this country did not come through a policy of frugality. Indeed it is just the opposite. The demand of the American public for something beyond the

"efficient" minimum is a characteristic difference between our country and others. Transportation is a product to be bought and used as is any other product, and the American public will select its transportation on the basis of what it wants and can afford, not what may be regarded as the most efficient. We insist on at least two bathrooms in our homes, on a radio in nearly every room, and in the car. We furnish the living room only to build a recreation room to furnish in the same way. We buy expensive cars when cheaper ones would provide equal transportation, and even pay to raise and lower the car windows by electricity. So it goes in every phase of American life. And, so why should we expect someone to use, in the name of efficiency, a form of transportation he does not want when he wants and can afford something better?

And finally, what the "pricing" theory perhaps overlooks is that a motor vehicle owner today pays over 10 cents per mile to own and operate his passenger car. Only about one cent per mile is tax, or in other words only 10 cents of the private transportation dollar is available for the planner to manipulate in an effort to discourage use. It would require substantial manipulation indeed of the 10 per cent to have a significant effect on the total cost of operation.

These preceding thoughts are more philosophical than economic and are expressed principally to support the belief that we are not likely to find in the near future, at least, arbitrary measures imposed on motor vehicle transportation in a conscious effort to retard its rate of growth. An important signboard pointing in this direction is seen in the 1956 Federal-Aid Highway Act, in which the Congress provided for the study of the cost of supplying highways for the various classes of users, and of the benefits derived by the users of the federal-aid systems. There is the obvious implication in this instruction that in deciding upon taxes to be imposed in the future on the various classes of users the Congress expects to be guided by costs or benefits or both in preference to arbitrary impositions.

Thus in this second principal area of competition between highway transportation and other forms of transportation it seems unlikely that the trend toward increasing use of the private vehicle will be reversed. Again, the stepped up rate of improvement of roads and streets in and around urban areas and the great population growth expected in the metropolitan fringes in the decades ahead would seem to favor a continuation of the trends of the recent past.

### The Broad View Ahead

In sum, we have a highway transportation system unlike any other form of transportation and destined always to be so. The roadway is provided by one or more of a multitude of public agencies which exercise but little control over the 80 million drivers of 67 million vehicles that use the highways. While the total of motor vehicle use may be viewed objectively, it is in fact the result of millions of individual decisions made day after day, most of them wholly subjective rather than objective, and mostly made with little regard to economic considerations, if we view economics in this case in its narrowest sense of direct cost involved.

As the result of the workings of this complex set of forces, economic, psychological, social, and many others, there has grown a system of transportation. And it has grown so steadily and uniformly over a generation that it has established very solid statistical trends. Faced with this complex assembly of forces one is tempted, as I am, not to try to appraise the effect of each if each could be identified, but to take the simple approach of assuming that the trends will continue unless some new and very powerful force, such indeed as a war, may be anticipated. And as of now I can foresee no such outside force to upset in appreciable degree the continuation of the established growth trends through the reasonably predictable future. The total of highway transportation is inextricably linked to the national economy, and even in the principal areas of competition there seems little likelihood of any early significant change. Highway transportation will continue to grow with the country.

That in general is the basis on which the Bureau of Public Roads is anticipating the future of highway travel. We have, of course, examined the overall growth prospects in a more refined manner than suggested by the "simplest" approach, and we are diligently examining ways to forecast the future demands on particular roads and on particular segments of systems for planning and design purposes. For the Interstate System, as an entirety, for example, estimates by the states and the Bureau show an increase in traffic from 1956 to 1975 of 168 per cent, yet on individual sections the estimated increases range from 25 to 500 per cent. For urban areas research is producing methods of estimating traffic through the relation of travel to land use to permit the rational planning of street systems and individual routes.

*(Continued on Page 14)*

# Bituminous Pretreated Aggregates For Bituminous Surface Treatment

By HOWARD M. BIXBY

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Washington, D. C.

### Introduction

ONE of the important problems faced by aggregate producers, contractors, and engineers is the dust created during the construction of a bituminous surface treatment and during the period following by traffic prior to the final clean-up of the work. Initially dust is present in the aggregate when delivered to the job and may, if in sufficient quantity, affect the adherence of the aggregate to the bituminous material. Some of this dust is carried into the air as the stone chips are spread on the bituminous surface. Following the application of the chips to the bituminous surface, additional fines are generated by the steel roller used to imbed the chips. After the initial rolling has been accomplished, traffic is permitted to use the treated surface. On a new surface treatment, before final maintenance rolling is completed, brooming of the cast off chips back onto the surface treatment in an effort to imbed them in the surface is a frequent practice. The dust contained in the aggregate, and the additional dust generated by some degree of degradation under the roller and traffic, is whipped up into the air by the traffic and results in numerous complaints. This is true on heavily traveled roads and more particularly in urban areas where complaints come from the adjacent property owners and residents as well as the traveling public. Because of complaints received from the citizens in Cincinnati, Ohio, when this type of work was being carried on, engineers of that city's Department of Public Works determined to do something about it. They believe that they have found a solution to the problem by an economical method of pretreating stone chips.

### Pretreatment Method

As a result of negotiations with a local crushed stone producer, equipment was set up to precoat the crushed stone with a bituminous material at the time of its production or before delivery to the job. Considerable experimentation was required to determine the type of bituminous material to use, and the rate at which it should be applied to the stone. The equipment used is a trough having a U-shaped cross section and is approximately 8 ft in length and 18 in. in width and depth. In the trough a screw conveyor revolves, acting both as a mixer and conveyor. The rear end of the screw conveyor, which is mounted in a horizontal position, is located just under the stone delivery chute of the stone chip bin, and a spray of

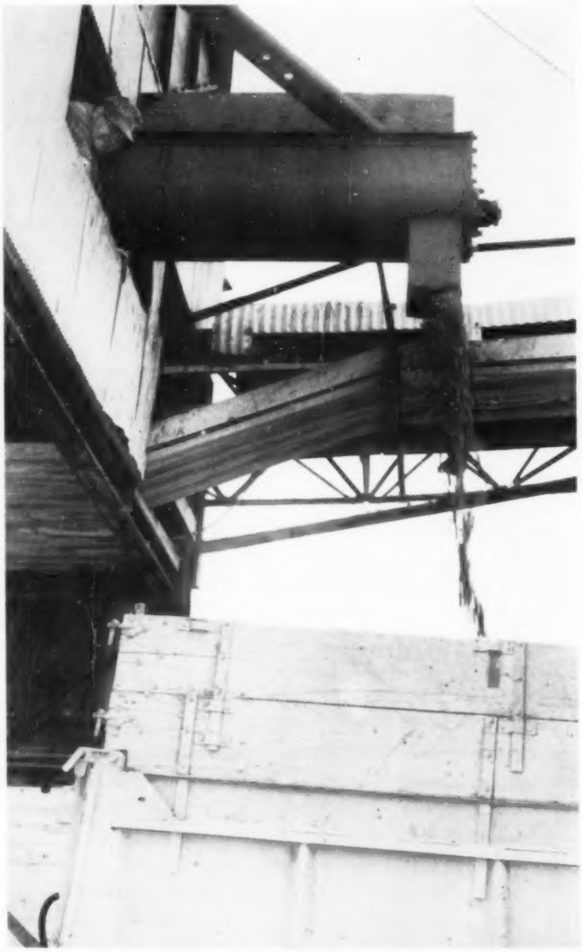

FIGURE 1
Screw Conveyor Discharging Precoated Stone Chips Into Truck

bituminous material is applied to the aggregate from a single short spray bar located transversely to the mixer immediately following the point where the chips enter the trough. The rotating screw mixes the crushed stone and the bitumen and at the same time conveys the mixture to the end of the trough (Figure 1), where it discharges by gravity through a short vertical chute in the bottom of the trough directly into a truck.

### Pretreatment Materials

The quantity of bituminous material applied, as determined by experiment, is one half of one per cent of the weight of the stone. On tar surface treatment, Ohio Primer T is used for precoating the stone. Ohio Primer T is a liquid water gas tar product having the following specification requirements:

| | |
|---|---|
| Engler Specific Viscosity at 40 C | 3.0– |
| Specific Gravity, 25 C/25 C | 1.03-1.10 |
| Total Bitumen (Sol. in $CS_2$), per cent | 96+ |
| Water, per cent by volume | 3.0– |
| Total Distillate to 300 C | 50.0– |

For asphalt surface treatments, the precoating material is a medium curing cut-back asphalt MC-O meeting Ohio State specifications. The screw conveyor will deliver approximately one ton per minute of treated aggregate at the discharge end and it is possible to precoat the stone whether it is wet or not. When the crushed stone is fed to the mixer direct from the production at the plant it is wet, when fed from a stockpile it may be dry or just damp. The aggregate is a crushed limestone material which meets the Ohio Department of Highways Size No. 6 gradation requirements, which are:

| Sieve Size | Per Cent Passing |
|---|---|
| 1/2 in. | 100 |
| 3/8 in. | 90-100 |
| No. 4 | 10-35 |
| No. 8 | 0-5 |

### Surface Treatment Method

Following the pretreatment of the stone chips, they are hauled to the job direct from the pretreatment plant for use in the surface treatment. The bituminous material is first applied to the surface to be treated by means of a conventional distributor, at the rate of 0.21 to 0.27 gal per sq yd, depending upon the kind of material selected and the type of surface to be treated. This is followed by the application of the stone chips to the bituminous coated surface with a self propelled aggregate spreader at a rate of from 15 to 17 lb of precoated chips per square yard. See Figures 2 and 3.

Immediately after the application of the stone chips, the surface is rolled and is then ready for use, although rolling may continue for a short period of time after traffic is permitted on the surface treatment.

FIGURE 2
Self Propelled Aggregate Spreader Applying Stone Chips

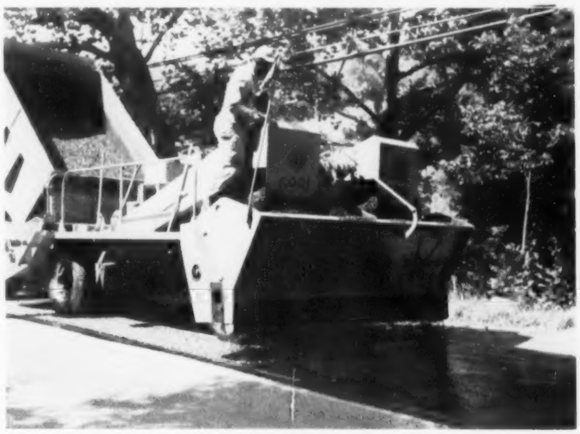

FIGURE 3
Front View of Self Propelled Aggregate Spreader

Because of the small percentage of bituminous material which has been added to the aggregate it is very difficult to see. The quantity used, however, is sufficient to hold onto the fines in the stone and is active in preventing dust resulting from the further action of rollers and traffic.

The following table shows the materials and rates of application used on most Cincinnati surface treatments.

| Type of Surface | Treated Aggregate lb/sq yd | Tar RT-8 gal/sq yd | Emulsified Asphalt RS-2 gal/sq yd |
|---|---|---|---|
| Hard Surface Pavements | 15-16 | 0.21-0.22 | 0.24-0.25 |
| Bituminous Macadam Pavements | 16-17 | 0.22-0.23 | 0.25-0.27 |

#### Cost of Pretreatment

In the early experiments a cost control system was set up to compare the cost of using pretreated crushed stone with untreated stone. One third of the surface treatment yardage was completed with pretreated stone and not one serious complaint was received from the public concerning the dust on the streets. The use of precoated crushed stone made it unnecessary to wet down the work to allay dust, as was the practice on untreated chips, and eliminated the flushing back of the excess chips and the removal of the chips from the street. This resulted in the over-all lowering of the material cost per square yard for surface treatment approximately 1 1/2 cents. The material cost for the work performed on streets with untreated stone includes the cost of wetting down, flushing, and the picking up of ravelled or unimbedded stone, but not the surface treatment labor and equipment costs generally. This cost for untreated aggregate was $0.0468 per sq yd. With pretreated crushed stone the cost for the material item, on which wetting down, flushing, and picking up was not necessary, was $0.0325 per sq yd. The actual average additional cost for the pretreatment of the crushed stone is approximately 90 cents per ton.

#### Conclusion

It was observed that the work performed using precoated aggregate resulted in a more dense and better appearing surface treatment than where untreated aggregate was used. This, it is believed, is the result of retaining not only the fines in the precoated mix, but also of preventing to a great extent the cast off by traffic of a portion of the stone chips. It was not necessary to adjust the bitumen applied per square yard for the surface treatment to compensate for the small percentage of bitumen used in the precoating of the aggregate. The experience in Cincinnati has been such that the use of precoated aggregate has been adopted exclusively for this type of work.

The material contained in this article was obtained from a paper by Arthur Lohrman, Supervisor of Inspection and Programming, and from information furnished by C. E. Heidschuch, Superintendent, both of the Maintenance Division of the Cincinnati, Ohio, Department of Public Works, to whom full credit is given.

## The Transportation Revolution: Highway Transportation

*(Continued from Page 11)*

But, to repeat, the total picture is the sum of all the myriad of individual parts, and without the ability to identify and predict the future of each, we are almost forced for the broad view of the future to the "simplest" methods. On this basis, and confirming the projections by various internal checks, the Bureau of Public Roads in 1955 estimated that in 1965 the motor vehicle registration would reach 81 million vehicles and the vehicle mileage 814 billion vehicle miles. Already we are questioning whether these values are high enough. In looking ahead at this time to 1975 we are anticipating at least 1.2 trillion vehicle miles of travel, an increase approaching 90 per cent of the 1957 figure.

Such figures are at best but guide posts to the future, for the exact shape and pattern of what lies ahead will be determined by the American people themselves as they move confidently ahead in an expanding economy to a more rewarding life. The most certain thing about the future is that it will not be static. Progress means change—change in many aspects of our economic and social structure—change in our very way of life. But it hardly seems likely that the place of motor vehicle transportation will be a factor of lesser importance in the future that we can foresee.

The highway engineer and administrator by their works today have a great and perhaps yet not fully recognized share of responsibility for the shape of America of the future. Very little that is done today in public or private life is as permanent in character as the highways they are building in the exploding metropolitan areas. Theirs is indeed an awesome responsibility.

## C. C. Beam

It is with deep regret that we announce the passing of C. C. Beam, President of The Melvin Stone Company, on April 19, 1958 at Wilmington, Ohio. Mr. Beam had been active in the National Crushed Stone Association since January 1923 and a member of the Board of Directors from 1935 to 1945. His passing will be a great loss to the entire industry and the Association he so enthusiastically supported.

# Save Maintenance Dollars By Preventing Excessive Wear on Your Tractors

ONE of the pressing problems facing all crushed stone producers is a way to reduce maintenance costs of tracked vehicles working in stone. The damage caused by stone working in between the track and idler or sprocket can in a rather short space of time become excessive and costly. Producers working tractors around the quarry or in storage piles expect rough wear on component parts and the track shoes in particular. Only a few passes to level out a storage pile can severely damage rollers, idlers, links, pins, bushings, and final drive sprockets.

Wide track shoes so necessary when working in mud or gumbo for flotation are important to some producers in certain areas. But it is the well designed narrow width shoes that have been universally accepted as best for quarry work. The greater overhang beyond the track link of the wide track shoes exerts more pressure against the outer edges. As a consequence the wide shoes are generally severely damaged when working in and around quarry operations.

The double grouser track shoes that can be obtained for use when work is being done almost exclusively in rock, help the shoe to resist bending or cracking by adding longitudinal strength.

Track shoe grouser wear will be faster on tractors equipped with two position idlers, when the idler is in the "low" position. By instructing drivers to hold the "low" position in reserve for use only when it is absolutely necessary, it will be found that track shoes will last considerably longer. Field experience has proven beyond any doubt that track roller guards very effectively protect the many individual parts of the track. Exhaustive tests have shown that there is very little damage, if any, done to track parts when tractors are equipped with track guards.

Tractors making turns in rock cause the rock to feed between the rollers and track. When the track moves forward or backward, a rather effective rock crushing action takes place. As the tractor moves forward stone is fed in between the sprocket and track; when the rig backs, the stone can feed in between the idler and track. This causes impact damage and severe abrasive action.

Even when track tension is correctly adjusted the damage described above will occur to tractors not equipped with track roller guards. The probability of excessive wear and damage, is of course, multiplied when the track tension is too great. Track recoil mechanisms are designed and built so that the sprocket can, under certain conditions, jump or skip

a tooth. This is done to minimize the possibility of extensive damage to the final drive. However when too much stone works its way into the track, the recoil mechanism will not permit the idler to travel far enough to feed the stone through. This stretching out of the track puts terrific strain and pressure on the track links, pins and bushings and causes unnecessary wear. The horsepower robbed as the result of track tension being too tight not only reduces the tractors' full productivity but may result in damage to the final drives.

In addition to keeping stone out of the tracks, track roller guards can materially help to keep tracks on the rollers in rugged terrain and minimize wear on the idler pilot rim and roller flanges.

Every crushed stone producer using tractors would be wise to reappraise the job conditions under which his tractors are working. Through a job reappraisal and by reconditioning all track components before they wear beyond the factory recommended limits, producers can insure a marked reduction in downtime as well as lower operating and maintenance costs.

# Manufacturers Division
# National Crushed Stone Association

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**These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.**

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**Allis-Chalmers Mfg. Co.**
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*Crushing, Screening, Washing, Grinding, Cement Machinery; Motors; Texrope Drives; Centrifugal Pumps; Air Compressors; Hauling Equipment; Engines; Tractors*

**American Cyanamid Co.**
**Explosives Department**
30 Rockefeller Plaza, New York 20, N. Y.
*Explosives and Blasting Supplies*

**American Manganese Steel Division**
**American Brake Shoe Co.**
155 North Wacker Drive, Chicago 6, Ill.
*Manganese and Alloy Steel Castings, Power Shovel Dippers, Material Handling Pumps, Reclamation and Hard-Facing Welding Materials, Automatic and Semi-Automatic Welding Machines*

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1249 Macklind Ave., St. Louis 10, Mo.
*Manufacturers of Ring Crushers and Hammermills for Primary and Secondary Crushing and Laboratory Sizes*

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*Dust Control Systems, Truck Bed Separating Agent*

**Arcair Co.**
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**Atlas Powder Co.**
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*Industrial Explosives and Blasting Supplies*

**Austin Powder Co.**
458 Rockefeller Bldg., Cleveland 13, Ohio
*Commercial and Industrial Explosives*

**Bacon-Greene & Milroy**
P. O. Box 5234, Hamden 18, Conn.
*"Farrel-Bacon" Jaw Crushers for Primary and Secondary Operations, Conveyors, Elevators, Rolls, Screens*

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**Barber-Greene Co.**
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*Primary and Secondary Crushers and Rolls*

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## Manufacturers Division – National Crushed Stone Association
(continued)

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**Construction Machinery Division**
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**Continental Gin Co.**
**Industrial Division**
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**Contractors and Engineers Magazine**
470 Fourth Ave., New York 16, N. Y.
*Magazine of Modern Construction*

**Cross Engineering Co.**
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**General Motors Corp.**
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*Heavy-Duty Trucks and Dump Trailers for "Off-Highway" Hauls, Loaders for Earth Excavation, Single and Twin Engine Earth Moving Scrapers, Crawler Tractors*

**Frog, Switch & Mfg. Co.**
**Manganese Steel Department**
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*"Indian Brand" Manganese Steel Castings for all Types of Jaw, Gyratory, and Pulverizing Crushers; Dippers, Teeth, Treads, and Other Parts for Power Excavating Equipment; and Other Miscellaneous Manganese Steel Castings. Manufacturers and Fabricators of Railroad and Mine Frogs, Switches, and Crossings*

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*Portable and Stationary Compressors, Rock Drills, "Air-Tracs," Self-Propelled Drills, Sectional Drill Rods and Accessories, Air Hoists, Slusher Hoists, "Mole-Drills," Paving Breakers, Drill Steel, Gads, Etc.*

**General Electric Co.**
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## Manufacturers Division – National Crushed Stone Association
(continued)

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**Division of Poor & Co.**
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*Oro Alloy and Manganese Steel Castings: For Shovels—Dipper Teeth, Crawler Treads, Rollers, Sprockets; For Crushers—Jaw Plates, Concaves, Mantles, Bowl Liners; For Pulverizers—Hammers, Grate Bars and Liners; For Elevators and Conveyors—Chain, Sprockets, Buckets; For Tractors—Rail Links and Grouser Plates; Drag Line Chain*

**Koehring Division**
**Koehring Co.**
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*Excavating, Hauling, and Concrete Equipment*

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*Vibrating Screens and Vibrating Conveyors*

**Link-Belt Co.**
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*Complete Stone Preparation Plants; Conveyors, Elevators, Screens, Washing Equipment, and Power Transmission Equipment*

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1201 Sixth St., S. W., Cedar Rapids, Iowa
*Complete Line of Speed-o-Matic Power Hydraulically Controlled Cranes, Shovels; Hoes, Draglines, and Clamshells, 1/2 to 3-Yd. Capacities; Available on Crawler Base or Rubber Tire Mounting; Diesel Pile Hammers*

**Lippmann Engineering Works, Inc.**
4603 West Mitchell St., Milwaukee 14, Wis.
*Primary and Secondary Rock Crushers and Auxiliary Equipment such as Feeders, Screens, Conveyors, Etc., Portable and Stationary Crushing and Washing Plants*

**Ludlow-Saylor Wire Cloth Co.**
634 South Newstead Ave., St. Louis 10, Mo.
*Woven Wire Screens of Super-Loy, Steel, Stainless Steel, and All Other Commercial Alloys and Metals*

**Mack Trucks, Inc.**
1355 West Front St., Plainfield, N. J.
*On- and Off-Highway Trucks, Tractor-Trailers, Six-Wheelers, from 5 to 100 Ton Capacity, Both Gasoline- and Diesel-Powered*

**Maclean-Hunter Publishing Corp.**
79 West Monroe St., Chicago 3, Ill.
*Publications: Rock Products and Concrete Products*

**Manganese Steel Forge Co.**
Richmond St. & Castor Ave.,
Philadelphia 34, Pa.
*ROL-MAN 11.00 to 14.00 Per Cent Rolled Manganese Steel Woven and Perforated Screens, and Fabricated Parts for Aggregate Handling Equipment*

**Marion Power Shovel Co.**
**Division of Universal Marion Corp.**
617 West Center St., Marion, Ohio
*Power Shovels, Draglines, Cranes, Truck Cranes—From 1/2 to 75 Yd.*

## Manufacturers Division – National Crushed Stone Association
(continued)

**Marsh, E. F., Engineering Co.**
4324 West Clayton Ave., St. Louis 10, Mo.
*Belt Conveyors*

**Mayhew Supply Co., Inc.**
4700 Scyene Road, Dallas 17, Texas
*Blast Hole Drill Rigs*

**McLanahan & Stone Corp.**
252 Wall St., Hollidaysburg, Pa.
*Complete Pit, Mine, and Quarry Equipment—Crushers, Washers, Screens, Feeders, Etc., Semi-Portable Plants*

**Meissner, John F., Engineers, Inc.**
308 West Washington St., Chicago 6, Ill.
*Engineers—Constructors—Specialists in Plant Layout, Construction-Engineering Design, Procurement, Construction Management, Quarry Surveys, Plant and Property Appraisals*

**Mercer Rubber Co.**
136 Mercer St., Hamilton Square, N. J.
*Belting—Conveyor, Elevator, and Transmission; Hose—Air, Water, Steam, Suction, Sandblast, Miscellaneous; Rubber Chute Lining*

**Monsanto Chemical Co.**
**Inorganic Division**
Lindbergh and Olive Street Road,
St. Louis 24, Mo.
*Prilled Ammonium Nitrate*

**Murphy Diesel Co.**
5317 West Burnham St., Milwaukee 14, Wis.
*Engines—Industrial Engine, and Power Units for Operation on Diesel and Dual Fuel Engines. Generator Sets, AC and DC from 64 Kw. to 165 Kw. Mech-Elec Unit—Combination Mechanical and Electric Power Furnished Simultaneously*

**New York Rubber Corp.**
100 Park Ave., New York 17, N. Y.
*Conveyor Belting: Stonore, Dependable, and Cameo Grades; Transmission Belting: Silver Duck Duroflex, Soft Duck Rugged, Commercial Grade Tractor*

**Nordberg Mfg. Co.**
3073 South Chase Ave., Milwaukee 7, Wis.
*Symons Cone Crushers, and Symons Gyratory and Impact Crushers; Gyradisc Crushers; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens and Grizzlies; Diesel Engines and Diesel Generator Units; Mine Hoists; Railway Track Maintenance Machinery*

**Northern Blower Co.**
6409 Barberton Ave., Cleveland 2, Ohio
*Dust Collecting Systems, Fans—Exhaust and Blower*

**Northwest Engineering Co.**
135 South LaSalle St., Chicago 3, Ill.
*Shovels, Cranes, Draglines, Pullshovels—Crawler and Truck Mounted*

**Olin Mathieson Chemical Corp.**
**Explosives Division**
East Alton, Ill.
*Explosives, Blasting Caps, Blasting Accessories*

**Pennsylvania Crusher Division**
**Bath Iron Works Corp.**
323 South Matlack St., West Chester, Pa.
*Single Roll Crushers, Impactors, Reversible Hammermills, Ring Type Granulators, Kue-Ken Jaw Crushers, Kue-Ken Gyratories, Non-Clog and Standard One-Way Hammermills*

**Pettibone Mulliken Corp.**
4710 West Division St., Chicago 51, Ill.
*Tractor Shovels, Front End Loaders, Swing Loaders, Yard Cranes, Bucket and Fork Loaders, Motor Graders, Manganese Steel Castings, Material Handling Buckets, Clamshells, Draglines, Pull Shovel Dippers, Shovel Dippers, and Pumps*

**Pioneer Engineering**
**Division of Poor & Co.**
3200 Como Ave., Minneapolis 14, Minn.
*Jaw Crushers, Roll Crushers (Twin and Tripple), Impact Crushers, Vibrating and Revolving Screens, Feeders (Reciprocating, Apron, and Pioneer Oro Manganese Steel), Belt Conveyors, Idlers, Accessories and Trucks, Portable and Stationary Crushing and Screening Plants, Washing Plants, Mining Equipment, Cement and Lime Equipment, Asphalt Plants, Mixers, Dryers, and Pavers*

## Manufacturers Division – National Crushed Stone Association

(continued)

**Pit and Quarry Publications, Inc.**
431 South Dearborn St., Chicago 5, Ill.
*Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Modern Concrete, Concrete Industries Yearbook, Equipment Distributor's Digest*

**Productive Equipment Corp.**
2926 West Lake St., Chicago 12, Ill.
*Vibrating Screens*

**Quaker Rubber**
**Division of H. K. Porter Co., Inc.**
Tacony and Comly Sts., Philadelphia 24, Pa.
*Conveyor Belts, Hose, and Packings*

**Reich Bros. Mfg. Co., Inc.**
1439 Ash St., Terre Haute, Ind.
*Rotary and "Down-the-Hole" Drilling Machines*

**Rogers Iron Works Co.**
11th & Pearl Sts., Joplin, Mo.
*Jaw Crushers, Roll Crushers, Hammermills, Vibrating Screens, Revolving Screens and Scrubbers, Apron Feeders, Reciprocating Feeders, Roll Grizzlys, Conveyors, Elevators, Portable and Stationary Crushing and Screening Plants, Mine Hoists, Drill Jumbos, Underground Loaders, and Iron Castings*

**Schramm, Inc.**
West Chester, Pa.
*Air Compressors, Rotary Drills, Pneumatic Drills, Etc.*

**Screen Equipment Co., Inc.**
40 Anderson Road, Buffalo 25, N. Y.
*Seco Vibrating Screens; Scales—Industrial, Aggregates, Truck*

**Simplicity Engineering Co.**
Durand, Mich.
*Simplicity Gyrating Screens, Horizontal Screens, Simpli-Flo Screens, Tray Type Screens, Heavy Duty Scalpers, D'Watering Wheels, D'Centegrators, Vibrating Feeders, Vibrating Pan Conveyors, Car Shake-Outs, Woven Wire Screen Cloth, Grizzly Feeders*

**SKF Industries, Inc.**
Front St. and Erie Ave.,
P. O. Box 6731, Philadelphia 32, Pa.
*Anti-Friction Bearings—Self-Aligning Ball, Single Row Deep Groove Ball, Angular Contact Ball, Double Row Deep Groove Ball, Spherical Roller, Cylindrical Roller, Ball Thrust, Spherical Roller Thrust; Tapered Roller Bearings; Pillow Block and Flanged Housings—Ball and Roller*

**Smith Engineering Works**
532 East Capitol Drive, Milwaukee 12, Wis.
*Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants*

**Soiltest, Inc.**
4711 West North Ave., Chicago 39, Ill.
*Laboratory and Field Testing Apparatus: Drilling and Coring Rigs, Sieve Shakers, Sieves, Scales, Balances, Calibration Equipment, Abrasion Testing Machines, Ovens and Furnaces*

**Sprengnether, W. F., Instrument Co., Inc.**
4567 Swan Ave., St. Louis 10, Mo.
*Portable Blast and Vibration Seismograph, and Scientific Instruments*

**Stardrill-Keystone Co.**
920 East 17th St., Beaver Falls, Pa.
*Drilling Machines: Rotary Air Drills, Churn Drills, Rotary Tools, Rotary Bits, Down-the-Hole Guns, Insert Type Bits, and Water Well Drills*

**Stedman Foundry & Machine Co., Inc.**
P. O. Box 209, Aurora, Ind.
*Stedman Impact-Type Selective Reduction Crushers, 2-Stage Swing Hammer Limestone Pulverizers, Multi-Cage Limestone Pulverizers, Vibrating Screens*

**Stephens-Adamson Mfg. Co.**
Aurora, Ill.
*Belt Conveyors, Pan Conveyors, Bucket Elevators, "Amsco" Manganese Steel Pan Feeders, Vibrating Screens, Belt Conveyor Carriers, Bin Gates, Car Pullers, "Sealmaster" Ball Bearing Units, "Saco" Speed Reducers, and Complete Engineered Stone Handling Plants*

**Taylor-Wharton Co.**
**Division Harsco Corp.**
High Bridge, N. J.
*Manganese and Other Special Alloy Steel and Iron Castings; Dipper Teeth, Fronts and Lips; Crawler Treads; Jaw and Cheek Plates; Mantles and Concaves; Pulverizer Hammers and Liners; Asphalt Mixer Liners and Tips; Manganese Nickel Steel Welding Rod and Plate; Elevator, Conveyor, and Dredge Buckets*

## Manufacturers Division – National Crushed Stone Association
(continued)

**Thew Shovel Co.**

East 28th St. and Fulton Rd., Lorain, Ohio

*"Lorain" Power Shovels, Cranes, Draglines, Clamshells, Hoes, Scoop Shovels on Crawlers and Rubber-Tire Mountings: Diesel, Electric, and Gasoline, 3/8 to 2-1/2 Yd. Capacities; Thew Moto-Loader—Rubber-Tire Front End Loader 1-3/4 Yd. Capacity*

**Thor Power Tool Co.**

Prudential Plaza, Chicago 1, Ill.

*Wagon Drills, Rock Drills, Sump Pumps, Clay Diggers, Paving Breakers, Quarry Bars, Sinker Legs, Drifters, Rock Drilling Jumbos, Raiser Legs, Push Feed Rock Drills, Air and Electric Tools, Accessories, Generator Sets, Power Trowels, Vibratory Screens*

**Torrington Co.**
**Bantam Bearings Division**

3702 West Sample St., South Bend 21, Ind.

*Anti-Friction Bearings; Self-Aligning Spherical, Tapered, Cylindrical, and Needle Roller; Roller Thrust; Ball Bearings*

**Tractomotive Corp.**

County Line Road, Deerfield, Ill.

*Rubber Tired Front-End Loaders (Tracto-Loaders)*

**Traylor Engineering & Mfg. Co.**

Allentown, Pa.

*Stone Crushing, Gravel, Lime, and Cement Machinery*

**Trojan Powder Co.**

17 North Seventh St., Allentown, Pa.

*Explosives and Blasting Supplies*

**Tyler, W. S., Co.**

3615 Superior Ave., N. E., Cleveland 14, Ohio

*Woven Wire Screens; Ty-Rock, Tyler-Niagara and Ty-Rocket (Mechanically Vibrated) Screens; Hum-mer Electric Screens; Ro-Tap Testing Sieve Shakers, Tyler Standard Screen Scale Sieves, U. S. Sieve Series*

**Universal Engineering Corp.**

625 C Ave., N. W., Cedar Rapids, Iowa

*Jaw Crushers, Roll Crushers, TwinDual Roll Crushers, Hammermills, Impact Breakers, Pulverizers, Bins, Conveyors, Feeders, Screens, Scrubbers. Bulldog Non-Clog Moving Breaker Plate and Stationary Breaker Plate Hammermills, Center Feed Hammermills. A Complete Line of Stationary and Portable Crushing, Screening, Washing, and Loading Equipment for Rock, Gravel, Sand, and Ore. Agline Plants. Asphalt Plants*

**Vibration Measurement Engineers**

725 Oakton St., Evanston, Ill.

*Seismographic and Airblast Measurements, Seismological Engineering, Blasting Complaint Investigations, Expert Testimony in Blasting Litigation; Nation-wide Coverage; A Complete Seismograph Rental and Record Analysis Service With "Seismolog"*

**Werco Steel Co.**

2151 East 83rd St., Chicago 17, Ill.

*Castings—Manganese, Alloy Steel; Screen Plates—Perforated Steel Screen Sections and Decks; Buckets; Chains; Belt Conveyors, Idlers; Dipper—Shovel; Drop Balls; Wire Cloth; Wire Rope and Related Products; Crushers, Pulverizers*

**Western-Knapp Engineering Co.**

50 Church St., New York 7, N. Y.

*Plant Design and Construction; Operating Studies; Appraisals*

**White Motor Co.**

842 East 79th St., Cleveland 1, Ohio

*On- and Off-Highway Trucks and Tractors—Gasoline- and Diesel-Powered; Industrial Engines—Gasoline and Diesel; Power Units, Axles, Special Machine Assemblies; Crane and Shovel Carriers; Power Generating and Distributing Systems; Batteries; All Classes of Maintenance and Repair Service*

**White Motor Co.**
**Autocar Division**

Exton, Pa.

*Motor Trucks*

**Wickwire Spencer Steel Division**
**Colorado Fuel and Iron Corp.**

575 Madison Ave., New York 22, N. Y.

*Wire Cloth, Screen Sections, Screen Plate—Perforated Steel, Wire Rope—Slings*

**Williams Patent Crusher & Pulverizer Co.**

2701-2723 North Broadway, St. Louis 6, Mo.

*Hammer Mills, Crushers, Pulverizers, Roller Mills, Reversible Impactors, Vibrating Screens, Air Separators, Bins, and Feeders*

# Technical Publications
### of the
# National Crushed Stone Association

## STONE BRIEFS

No. 1. How to Proportion Workable Concrete for Any Desired Compressive Strength

No. 2. How to Proportion Concrete for Pavements

No. 3. Uses for Stone Screenings

No. 4. How to Determine the Required Thickness of the Non-Rigid Type of Pavement for Highways and Airport Runways

No. 5. The Insulation Base Course Under Portland Cement Concrete Pavements

## ENGINEERING BULLETINS

No. 1. The Bulking of Sand and Its Effect on Concrete

No. 2. Low Cost Improvement of Earth Roads with Crushed Stone

No. 4. "Retreading" Our Highways

No. 5. Reprint of "Comparative Tests of Crushed Stone and Gravel Concrete in New Jersey" with Discussion

No. 7. Investigations in the Proportioning of Concrete for Highways

No. 9. Tests for the Traffic Durability of Bituminous Pavements

No. 11. A Method of Proportioning Concrete for Strength, Workability, and Durability. (Revised November 1953)

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*Single copies of the above publications are available upon request.*

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